

HYBRID X-RAY DIFFRACTION FOR ANALYSIS OF UNPREPARED SAMPLES IN PLANETARY EXPLORATION

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The next NASA Mars Rover (Mars Science Laboratory) will be equipped with a miniature powder XRD instrument called CheMin. Installed onboard the rover, it requires delivery and grinding of samples collected on the ground by the robotic arm. In order to relax the requirements for sample preparation and handling in future missions, a new type XRD planetary instrument is being developed based on a hybrid concept that allows performing powder and single-crystal XRD measurements, making it possible to analyze minerals with limited or no sample preparation. Powder XRD (pXRD) will be used when fine-grained samples are presented to the instrument, either in their native state or after preparation with a grinding tool. Single-crystal XRD using polychromatic radiation (Laue diffraction) will be applied when samples are too coarse for pXRD. Laue analysis will allow identification of minerals in unprepared samples and enable ab-initio determination of crystal structures not in current crystallographic databases. The challenges of peak indexing in a Laue diffraction experiment will be overcome with application of an energy-dispersive CCD, which provides information about the lengths of reciprocal lattice vectors.

A preliminary design was investigated to demonstrate the potential of the Laue method for mineral identification. A breadboard instrument was built to test the Laue diffraction capabilities with energy-dispersive CCDs, and software was developed for crystallographic interpretation of these data. This work confirmed that the Laue method can be used for mineral identification. A planetary instrument breadboard is under development using a miniature 25kV X-ray tube combined with a cluster of 2D detectors collecting the diffracted signal over a large solid angle. The same detectors are used to collect either diffraction rings of powder data or Laue diffraction spots. In parallel to the hardware development, software for data processing and crystallographic analysis is being developed and interfaced to the American Mineralogist Crystal Structure Database (AMCSD).